Surface Fluxes under Weak Wind Conditions

Larry Mahrt
College of Oceanic and Atmospheric Sciences
Oregon State University
Corvallis, OR 97331
phone: (541) 737-5691 fax: (541) 737-2540 email: mahrt@coas.oregonstate.edu

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LONG-TERM GOAL

The long terms goals include re-examination of the applicability of Monin-Obukhov similarity theory and the Charnock formulation over the sea, the influence of wave state on such relationships and the vertical structure of the marine boundary layer in response to changes of SST.

OBJECTIVES

We propose to examine each of a number of physical mechanisms thought to be important for weak wind conditions by collecting aircraft and tower data in both open-ocean and fetch-limited conditions. This investigation relies on eddy correlation data from both aircraft and towers. Our contention is that existing analyses for weak wind situations are often strongly influenced by observational errors and analyses problems, which will be given special emphasis in this study.

APPROACH

In addition to analysis of the LongEZ eddy correlation data in the CBLAST Weak Wind Experiment 2001, we have employed eddy correlation on the CBLAST WHOI ASIT tower. We will analyze this data as well as eddy correlation data collected by the CIRPAS Pelican. The processed data will be analyzed toward the goal of improving physical understanding and parameterization of sea surface fluxes and will be provided to LES and larger-scale modeling groups.

WORK COMPLETED

Quality control and recalibration of the 2001 LongEZ data were completed in the previous year. Several studies based on analysis of the 2001 data are underway. One study focuses on the depth of the marine boundary layer and relation to the low level jet. Another study is concentrating on the relationship of fluxes to variations of SST. The latter study includes case studies for 7 and 8 August. Both days are characterized by downward heat flux and presumed warm air advection.

Eddy correlation measurements of heat, moisture and momentum have been deployed on the ASIT tower in the 2003 CBLAST Weakwind Experiment.

RESULTS

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Observational errors and solutions for the LongEZ data collected in 2001 were reported in the 2001 annual report. Overall, the LongEZ data appears to be of high quality, particularly after making the adjustments noted in the report. The preliminary analysis indicates that the usual Charnock relationship seriously over predicts the surface stress and that this over prediction is not related to semi-collapse of the turbulence in offshore advection of warm air, as in some previous studies.

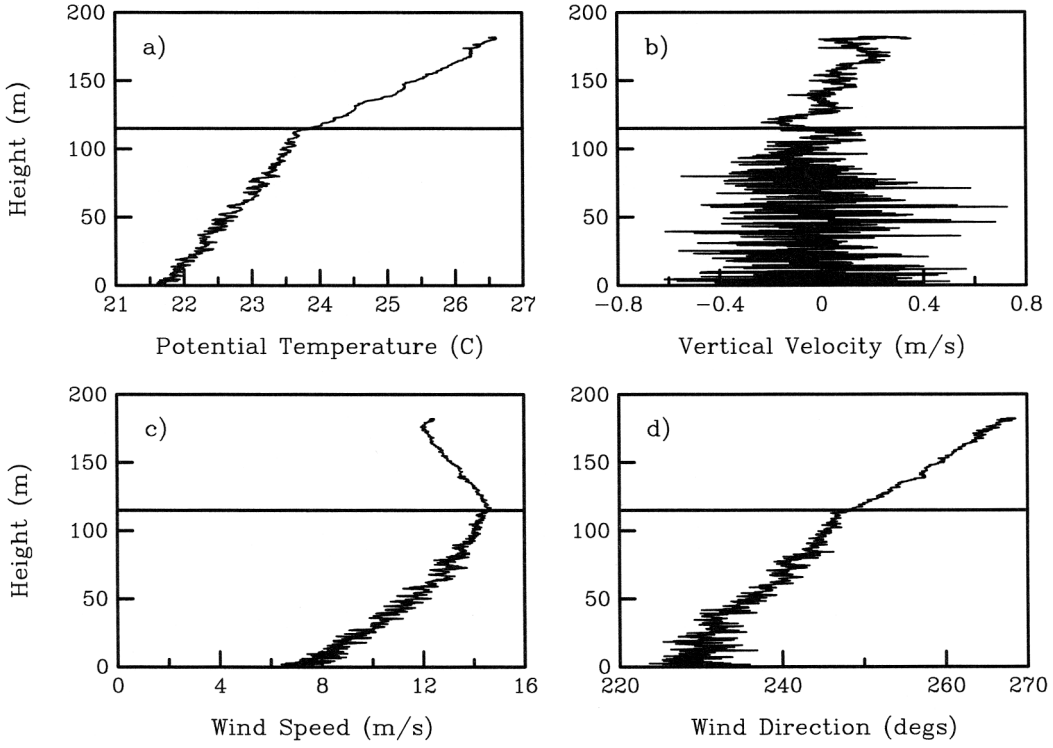

Figure 1. A vertical profiles collected by the LongEZ aircraft on 7 August 2001. Such a low-level jet was observed on about 1/3 of the flights, usually with southwesterly flow, and extended over the entire CBLAST Weak Wind study region (roughly 30 x 30 km) with only small spatial variation.

The 2001 data indicate very well defined low-level jets with offshore flow (Figure 1). The wind decreases rapidly with height above the wind maximum in contrast to the usual nocturnal low-level jet where the strong shear is normally confined to the underside of the wind maximum. The turbulence extends up to near the wind maximum but vanishes at the wind maximum. The cause of the low-level jets has not yet been determined although reduced drag over the sea, partly due to advection of warmer air over cooler water, is expected to contribute.

When the air-sea temperature difference becomes large positive (several degrees), the boundary layer becomes thin and poorly defined. The time scales for response of the boundary layer to SST changes are being examined. The depth of the stable marine boundary layer has been compared with 14 different diagnostic formulations. All of the diagnostic models perform poorly. Approaches based on a bulk Richardson number perform best. However, the value of the critical Richardson number must be reduced compared to the usual values, apparently due to the very small roughness lengths over the sea surface.

Errors due to fluctuations of platform height with buoys and aircraft are found to be generally small but not sufficiently predictable to construct criteria. Much of the platform displacement error is random and can be reduced by applying flux-sampling criteria.

IMPACT/APPLICATIONS

The analysis of the 2001 data indicates that research aircraft are of limited use for measuring surface fluxes in very stable conditions in the coastal zone, even with aircraft flights as low as 10 m above the sea surface. The boundary layer may be only 10-20 m deep in which case fluxes at the aircraft level are much different than surface fluxes.

RELATED PROJECTS

In "Spatial Variations of the Wave, Stress and Wind Fields in the Shoaling Zone**"** (N000149710279), we are evaluating different simple formulations of the surface stress using a variety of coastal zone data sets. The grant ended 1 October 2003.

PUBLICATIONS

Mahrt, L., D. Vickers, W. Drennan, H. Graber and T. Crawford, 2003: Fluxes measured from moving platforms. To appear in *J. Atm. and Oc. Tech.* [in press, refereed]

Vickers, D. and L. Mahrt, 2003: Evaluating formulations of stable boundary-layer height. *J. Appl. Meteor.* [submitted, refereed]